

DEVELOPMENT AND TEST OF A LARGE-APERTURE Nb_3Sn COS-THETA DIPOLE COIL WITH STRESS MANAGEMENT*



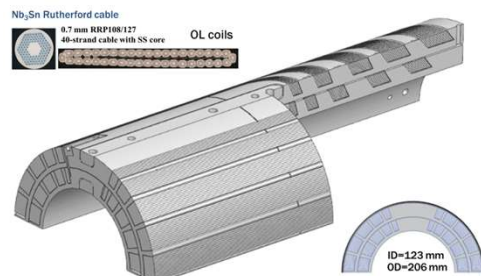
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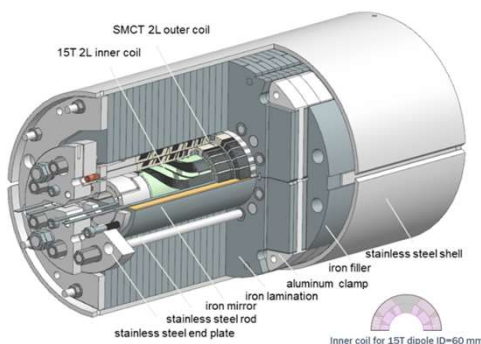
Introduction

An innovative stress-management (SM) concept for cos-theta (CT) coils (SMCT coil concept) has been proposed at Fermilab. A large-aperture two-layer Nb_3Sn SMCT dipole coil was designed and manufactured to validate and test the SM concept including coil design, fabrication technology, and performance. The first large-aperture SMCT coil (SMCT1) was fabricated and assembled with a small-aperture Nb_3Sn coil inside a dipole mirror magnet. SMCT1 coil tests in a dipole mirror structure was performed in two configurations - SMCTM1a with only powered two-layer SMCT1 coil and SMCTM1b with the SMCT coil connected in series with an inner two-layer dipole coil. The test goals are to prove the SMCT coil concept in two-layer and four-layer mirror configurations; demonstrate that the magnet can reach the targeted quench current at the established preload; study magnet training, training memory after thermal cycle, ramp rate and temperature dependences of the magnet quench current; and test the SMCT1 coil quench protection parameters. This paper summarizes the SMCT1 coil design and parameters, the coil main fabrication steps, its assembly in the dipole mirror structure. The results of the SMCTM1a/b mirror test are presented and discussed.

SMCT1 COIL & MIRROR DESIGNS

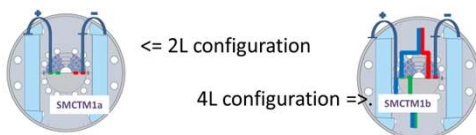


Nb_3Sn cable and SMCT1 coil parameters.



3D view of the 4L dipole mirror magnet.

TEST CONFIGURATIONS



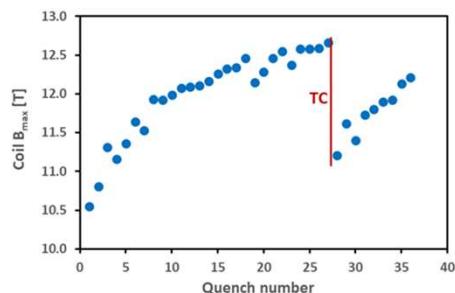
SMCT1 coil test configurations.

CONCLUSION

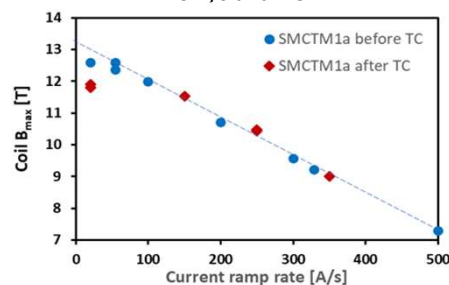
The first large-aperture Nb_3Sn SMCT1 dipole coil was designed and built at Fermilab to validate and study the SM coil concept. The SMCT1 coil was tested in two dipole mirror configurations. In the first test, after a relatively short training, the SMCTM1a mirror magnet with the SMCT1 coil powered individually, has reached a B_{max} in the coil of 12.7 T at 1.9 K and 12.0 T at 4.5 K which corresponds to ~90% of its SSL. After TC the magnet re-training started at 11.2 T showing some loss of its training memory. However, no conductor degradation was found after TC. The possible causes of magnet re-training are being studied and the effort will be made to improve the situation in the next coils. In the four-layer SMCTM1b configuration, the B_{max} reached in the SMCT1 coil at 1.9 K was 12.6 T at the B_{max} in the inner MDP coils of 14.5 T. The SMCTM1b magnet performance was limited by the inner coil. Successful demonstration of the SMCT coil shows that this design approach open possibilities of large-aperture high-field dipole and quadrupole magnets for Muon Collider and other applications such as 2nd IR for EIC.

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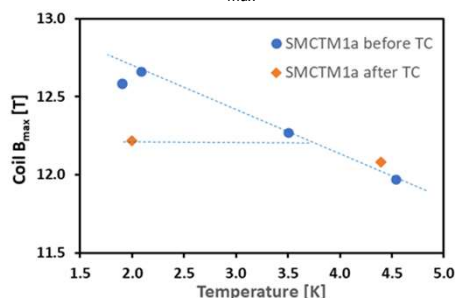
SMCT1 COIL TEST



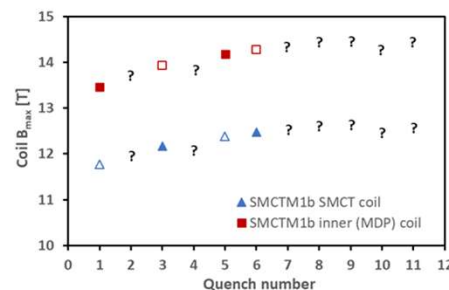
SMCT1 coil B_{max} vs. quench number at 20 A/s and 1.9 K.



SMCT1 coil B_{max} vs. dI/dt at 1.9 K.



SMCT1 coil B_{max} vs. T in SMCTM1a.



SMCT1 and MDP coil B_{max} vs. quench number at 20 A/s in SMCTM1b at 1.9 K. Quenches with voltage spikes detected in both coils are shown by question marks.

SMCT1 COIL TEST SUMMARY



SMCTM1a test with TC:

- relatively short training
- poor training memory
- I_q degradation ~9%
- no degradation after TC
- B_{max} at 1.9 K in the SMCT1 coil 12.7 T

SMCTM1b test:

- current and voltage spikes
- B_{max} in the SMCT1/MDP coils 12.6/14.5 T
- performance limitation by the inner (MDP) coil